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ENERGY EFFICIENCY MEASURES IN THE FISHING FLEET

(ENERGIEFFEKTIVISERING I FISKEFLÅTEN)

BY

AAGE BERG

REPORT NO. A 43

INSTITUTE OF FISHERY TECHNOLOGY RESEARCH
(FISKERITEKNOLOGISK FORSKNINGSINSTITUTT, FTFI)

TRONDHEIM / TROMSØ
NORWAY

PROJECT NUMBER 2200 (662.5)

SUPPORTED BY: NORWEGIAN FISHERIES RESEARCH COUNCIL
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ABSTRACT.

" Energy Efficiency Measures in the Fishing Fleet " started in 1980 as a separate research program with financing from the Norwegian Fisheries Research Council (NFFR). The program was concluded in 1986.

The overall objective of the program has in this period been the following: " To reduce the effect of increasing oil prices by assessing the influence of increasing oil prices on various fishing methods and by developing and implementing methods for reducing the oil consumption of new and existing fishing vessels".

The work that has been performed on the program can be divided into three stages:

1. Operation of existing vessels. How the current fleet can be better operated.
2. New construction and rebuilding of vessels. Better technical solutions.
3. Evaluation of changes in relative profitability between groups in the fleet as a result of increases in the oil price.

Three key words:
Fishing vessels
Energy efficiency
Propulsion

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1.0. INTRODUCTION

" Energy efficiency in the fishing fleet" started in 1980 as a separate research program.

In the period 1982 - 84 the program was part of the NORDFORSK "Oilfish" program where research in this field in Denmark, the Faroe Islands, Iceland and Norway was coordinated.

The overall objective of the program has for this period been the following:

To reduce the effect of increasing oil prices by assessing the effect of increasing oil prices on various fishing methods and by developing methods for reducing the oil consumption of new and existing vessels.

This objective was to be met through:

- The development of better hull types with a lower resistance to the water.
- Development of propulsion systems that require less energy during fishing operations and travel to and from the fishing grounds.
- Development of methods, equipment and instrumentation that makes it possible to achieve a more energy efficient utilization of machinery, vessels and fleet.
- To reduce the negative effects of increasing oil prices by assessing the effect of increasing oil prices on various fishing methods. To analyze short- and long term effects of the oil price increase.

The work that has been performed under this program can (p.3 be divided into three stages:

1) The operation of existing vessels. How can the fleet of today be operated more efficiently?
2) New construction and rebuilding of vessels. Better technical solutions.

3) Assessing changes in relative profitability between fleet groups as a result of an increase in the price for oil.

In all these areas the increased oil prices have resulted in a demand for changes to operational practices established when oil prices generally were less than half of those today.

The preliminary work uncovered a considerable potential for reductions in the oil consumption, and when the NORDFORSK cooperation was established, the long term objective established was that the amount of fuel necessary to catch a certain amount of fish should be halved relative to the consumption in 1978/79.

Of concrete projects that have been undertaken can be mentioned:

- Mapping the energy consumption in the fishing fleet.
  On macro level: From available statistics.
  On micro level: From measuring devices onboard vessels.
- Development of methodology for analysing the choice of speed and transportation economics for fishing vessels.
- Devices and procedures to be used onboard for correct use of engine and controllable pitch propeller, and for correct choice of speed.
- Fuel simulator designed as a teaching aid for instructing fishermen of correct use of engine and controllable pitch propeller and also on optimum choice of speed.
- Rebuilding the propulsion system (increase the diameter of the propeller and gearing down).
- Shape of the hull; model tank trials and full scale trials to determine any reduction in water resistance in still water and in waves (seas).
- Computer model for calculating the fuel consumption for a given vessel construction in a specified fishery.
- Information and decision system for use onboard to give the skipper better opportunities to make decisions on the choice of fishing grounds.
- Seminars and information activity for fishermen and others

to disseminate knowledge on opportunities for saving.

"Energy efficiency measures for the fishing fleet" was terminated as a separate program in 1986.

It has been found expedient in this report to include a list of working notes and reports generated by this program and by projects that are closely related to this program, but are financed from other sources.

2.0. SUB PROJECTS. SUMMARY. (p.5)

The program has in this period been divided into the following sub projects:

Year	Project:	662.5-1	662.5-2	662.5-3	662.5-4
1980		A	B	C	E
1981		A	B		
1982		A	B	D	
1983		A	B	D	F
1984		A	B	D	F
1985			B		F
1986			B		F

Activities:

A- "Energy efficiency in the fishing fleet".
B- "Resistance, propulsion and operational control".
C- "Machinery and systems development".
D- "Tactical resource projections".
E- "Recovery of waste heat".
F- "Operational instrumentation and measurements for fuel efficiency".

It can be seen from the table that only sub-projects 662.5-2 (B) and 662.5-4 are active in the concluding year 1986.

3. ENERGY EFFICIENCY IN THE FISHING FLEET. (p.6)

Sub project A (662.5-1).

This sub-project was carried out in the period 1980 -84. Objectives can be summarized in the following main points:

- Develop methods for performing technical and economical analyses of the energy efficiency of fishing vessels.
- Clarify conditions regarding energy consumption in the fleet and determine negative consequences of oil price increases on the profitability of the fishing fleet, and which measures can be taken to counter them.
- Inform the industry on how the use of the vessel influences energy consumption and economic results of operations.

Results.

Thorough studies of the importance of speed reduction for fuel consumption have been carried out.

In addition, the basis for calculating economic speeds for various vessels and gear types has been laid.

To inform the industry of fuel saving measures in the long or short term, a number of talks have been held on these problems (included in the list of references).

An analysis of operational economics for alternate methods of generating electricity on smaller vessels has been made. (Ref. A.8).

Based on the cost and earnings studies issued by the (p.7) Budget Committee for the Fishing Industry, summary data on the energy consumption of various fishing methods have been calculated for the period 1971 - 80. (Ref. A.12 and A.14).

Analyses have been made of the consequences of the dramatic rise in oil prices that occurred in 1979 - 80 and measures implemented to counter these.

Analyses of the consequences of, and measures to meet the oil price increases were made in several areas:

- On the operational side. Choice of speed and use of

propulsion systems.

- Choice of engine size based on power requirement in the free running mode.
- Choice of main dimensions for the hull.
- Change in competitive ability between fishing methods with different energy consumption.

The work performed in these fields is documented in working papers and reports in 1980 - 81.

Based on the cost and earnings studies of the Budget Committee, energy consumption and energy efficiency for 10 major groups in the fleet can be calculated (Ref. A.17 and A.20).

The calculations in the report show that the fuel consumption in kg oil per kg catch (the energy coefficient) is relatively stable for the various gear type groups up to and including 1979, and that there was a reduction in the coefficient for most of the gear types in 1980. The reduction is especially large for the purse seine and trawler fleet.

Sales statistics from the oil companies show a total drop of 13% from 1978 to 1980 and ca. 25 % from 1980 to 1981.

In 1980 - 81 work commenced on establishing (p.8) necessary instrumentation and data logging systems for the collection of effect profiles for fishing vessels. From 1983 this work was performed under the project 662.5-4 " Operational instrumentation and measurements of fuel efficiency" (F).

Results from the full scale registrations performed have also been utilized in project 662.5-2 "Resistance, propulsion and operational control". The prototype vessel used was "Kystfangst", while the registrations were done on a purse seiner and two trawlers. Such registrations are also financed externally.

The measurement programs have two purposes:

a) To measure characteristics of the propulsion system of the vessel.

b) To produce effect profiles of the fishing method used by the vessel (operational profiles).

The collection of the data was done until the end of 1984 in that FTFI received data cassettes from the instrumented vessels. These cassettes contain information on speed, consumption, revolutions, propeller pitch etc.

The vessels have been equipped with registration equipment that measures and stores the data continuously during operations.

An analytical program has been developed to handle these data . It is described on page 41.

Talks have been held on the consequences of technological development and energy price increases (A.9 and A.10). For example, the costs of landing fish by fresh fish trawling and nearshore longlining are compared considering various variables such as catch rates, energy price and technological developments.

Work has also been done on mathematical formulation of analytical methodology for choice of speed, engine size and choice of hull dimensions. A simple use of the methodology is demonstrated in an analysis of freight costs in the purse seine fleet (Ref. A.11).

The analytical methodology can be used for:

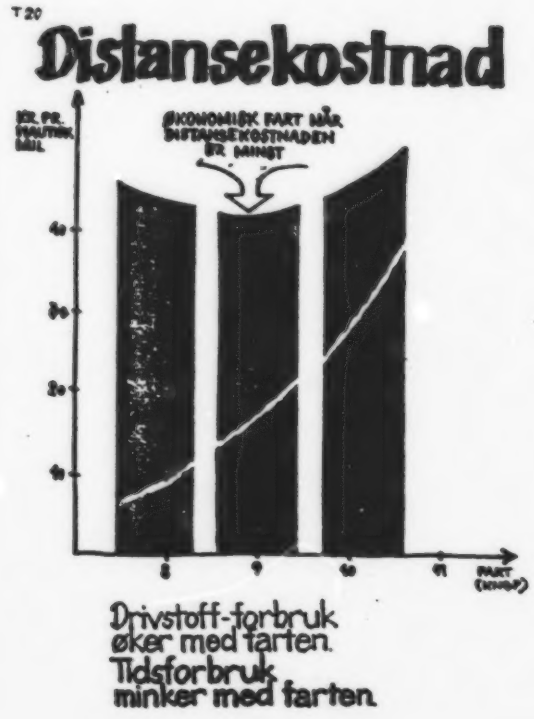
a) Determination of economical speed, either simplified from calculated or measured characteristics for the vessel, or integrated in instrumentation onboard.

b) Analysis of economically installed engine effect when speed requirements are dimensioned for engine.

c) Analysis of main dimensions for vessel and propeller in a given operational mode.

DISTANCE COSTS Economical speed when distance costs are smallest

Kr.per nautical mile.



Fuel consumption increases with the speed.
Time used decreases with the speed.

In the Nordic cooperative research project "OIL-FISH", the Vessel Technology Laboratory in Denmark has developed a model that can calculate the oil consumption of a vessel from a detailed technical description and the operational cycle.
The result of this work is a computer program that has been further developed on Iceland. A version of the program will according to the plan be brought to FTFI and installed on VAX.

The program will, for example, make it possible to analyze alternative solution for engines and other machinery.

Work has been done on the development of an ecopilot system.

Ecopilot is a device for regulating correct use of engine and propeller automatically or semi-automatically. Two strategies have been explored for this regulation:

- Minimum-search for measuring speed and tension when there is a change in admission.

- Determination of pitch from propeller loading measurements.

In the same period Siemens and Liaaen Helitron worked on their own concept for an ecopilot. FTFI applied for funds for "Testing of ecopilot systems" (672.198) in cooperation with these companies. This project was underway in 1986 and included tests with the systems onboard two fishing vessels. So far the Siemens system on M/V Eros has been partly tested. Application has been made for further funding in 1987.

A considerable effort has been placed on information dissemination in the project period in connection with the project "Economical operation of engine and propeller during trawling" where instrumentation, vessel charter costs and parts of salary costs were financed by the OIL/FISH Fund.

The characteristics of the propulsion systems on two trawlers were determined through measurements onboard. The purpose was to show how different use of the installations can affect the oil consumption, and what is correct use during towing and in the free running mode. The results showed that incorrect use can lead to additional oil consumption of up to 20 - 30 %.

A series of seminars were held for trawler officers (skippers, mates, engineers, inspectors) in the fall of 1983 in Stamsund, Myre, Harstad, Tromsø, Aalesund, Aakrehamn and Egersund. Results from the project were presented at these seminars (Ref. A.15-A.17). The seminar had two parts; one with lectures and a practical demonstration part onboard the test vessels.

This format, with seminars for selected audiences where theory and practical demonstrations were combined, turned out to be a very effective method to disseminate information.

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The experiences from these seminars led FTFI to (p.12) proceed further with planning of a broader information campaign on fuel savings in the fishing fleet. This campaign started in 1984 and was financed by Efficiency Improvement- and OED funds and is continuing into 1987. (Ref. A.27).

The dissemination of information to fishermen on how fuel consumption is affected by the use and the construction of fishing vessels is a key to the reduction of consumption. To assist in this dissemination, a prototype of a fuel consumption simulator has been developed. The simulator was developed around a micro-computer that performs resistance calculations and propeller calculations (for controllable pitch propellers) and also incorporates the consumption characteristics of the diesel engine. The simulator was constructed like the control panel of a fishing vessel.

In the beginning we worked with a company that was to produce a small series of the simulators for placement in schools. This cooperative arrangement has now been terminated and we have re-allocated the remaining funds (Efficiency Improvement Fund) to convert the simulator program to a standard PC. This work has now been completed, and the simulator program can be run on an IBM - AT- compatible PC.

The part of the project that included measurements and instrumentation was segregated as a separate project, 662.5-4 from 1/1-1983 under the title " Operational instrumentation and measurements for fuel efficiency".

Work planned but not completed when this report was written includes:

- A computer program for analyses of collected operational profile data is operational. The data have not been analyzed. This program could be suitable for a student project.

- Computer program for diagnosis calculations. The program has been started and almost completed within the information campaign. Some programming work remains at the end of the year 1986/87.

3.1. Documentation 662.5-1 (A)

(A.1) Torbjørn Digernes: Speed and fuel economy in fishing vessels.
FTFI Report, Dec. 1979.

(A.2) Torbjørn Digernes and Anders Endal: Fishing vessel speed and fuel economy. Talk held at ICES meeting in Reykjavik, May, 1980.

(A.3) Torbjørn Digernes: Fuel saving program in the fishing fleet FTFI Note 3/7-1980

(A.4) Torbjørn Digernes: Fuel saving through speed reduction. What is correct speed? Talk held in Aalesund 25/6-1980.

(A.5) Torbjørn Digernes: Survey of energy consumption and energy intensity data requirements. FTFI- working paper 14/2-1980.

(A.6) Torbjørn Digernes: Distribution of subsidies for cost reducing measures in the fishing fleet in 1980. Assignment report 12/6-1980.

(A.7) Torbjørn Digernes: Oil price increases and oil saving in the fishing fleet. Talk on NIF course in Aalesund 2/12-1980.

(A.8) Lars Nestaas: Economical analyses of generator operation.
FTFI Working paper.

(A.9) Anders Endal: Technological developments and energy price increases; opportunities and challenges. Talk at NIF-course in Molde 27-29/4-1980 (30 p.)

(A.10)Torbjørn Digernes: Technological developments and energy price increases;how is the fleet affected? Talk at NIF course in Molde 27-29/4-1980 (29 p.)

(A.11)Torbjørn Digernes: Freight rates for the transportation arrangement in the purse seine fleet. FTFI Report, 25/5-1981. (22 + 31 p.)

(A.12) Hans Erstad: Energy consumption in the Norwegian fishing fleet in the years 1971-78. Working Paper 14/9-1981 (34 p.)

(A.13) T. Digernes: An Analytical Approach to Evaluating Fishing Vessel Design and Operation. Report 4/1-1982. (ca. 140 + 50 p.)

(A.14) H. Erstad: Energy consumption in the Norwegian fishing fleet 1971-1980. FTFI Report, July 1982 (28 p.)

(A.15) Aage Berg: Use of engine and propeller. Improvements when rebuilding the propeller system. 9/12 - 1982.

(A.16) Ivar Bjørkum: Running a diesel engine with a part load. 9/12 - 1982.

(A.17) T. Digernes: How can we choose the right speed? 9/12 - 1982.

(A.18) T. Digernes: Fuel saving campaign in the fishing fleet. Initiatives and budget. Note 10/6 - 1983.

(A.19) I. Kjerstad: The profitability of a propeller change. Working Paper 15/10 - 1983.

(A.20) T. Digernes: Energy efficiency in the fishing fleet- results and further work. Note 19/12 - 1983.

(A.21) I. Kjerstad: Profitability evaluations of the energy saving investments. FTFI Note 14/5 - 1984.

(A.22) Fact Sheets: Full speed is expensive: Slow down.
Use the controllable pitch propeller correctly.
Engine and propeller: a teamwork.
Save with bulb.
Large propeller - fuel savings -less noise.
The fuel meter - the key to oil savings.
Metering fuel with a stopwatch.
Investments in oil saving - does it pay?

(A.28) Aa. Berg: Information campaign on fuel savings in the fishing fleet. Part II. FTFI Working Paper, 18/7 - 1986.

(A.29) Anton K. Iversen: Fuel saving in the fishing fleet. Proposal for a textbook for secondary schools with relevant fisheries education. May 1986.

(A.23) T. Digernes: Energy efficient operation of fishing vessels - methods and equipment. Talk given at an "Oil/Fish" Seminar, 10/9 - 1984.

(A.24) L. Waerdahl: Propulsion engines for fishing vessels. Report, Dec. 1984.

(A.25) I. Kjerstad: Profitability evaluations of a conversion to heavy oil use on a fishing vessel. Working paper, November 1984.

(A.26) Anon: Facts on fuel saving. Course text for fuel saving course for fishermen.

(A.27) Aa. Berg: Information campaign on fuel savings in the fishing fleet. Part I. Report FTFI 672.5 from March 1986.

4.0 RESISTANCE, PROPULSION AND OPERATIONAL CONTROLS.

Sub project B (662.5-2).

This sub - project started in 1980 and is a continuation of earlier projects from the end of the 1970's.

Objectives for this project has in this period chiefly been as follows:

- The project has been aimed at minimizing the power requirements for driving modern fishing vessels.

- The resistance of vessels with extreme length/depth ratios should be determined.

Systematic model trials should be performed to determine the relationship between propulsion (power) and resistance in still water and in waves. The key word here was the variation in the main dimensions of hull and propeller.

- Full scale measurements should also be taken in use to elucidate propulsion properties for various parts of the fishing fleet.

- The project should also evaluate possibilities for converting fishing vessels with a view of improved propulsion in still water and waves.

Results.

Early in the project period, model tank experiments were performed in still water with 6 different bulbous bows on an 80 feet fishing vessel. The largest reduction in resistance in the speed range 9 - 10 knots was about 12% (Ref. B.4).

Trials were later done on an 110 feet vessel (Ref. B.7, B.9 and B.14) with various bow shapes in waves.

From these trials it was found that an 10 - 12 % (p.17) reduction in resistance was the upper limit of what could be achieved with a conventional bulbous bulb.

Vessels in the 110 ft. class were tried in seas corresponding to gentle breeze to fresh breeze. These trials showed that the propulsion effect in waves is up to 10 times as high as in still water in speeds corresponding to 4 - 6 knots.

For higher speeds the propulsion effect is typically 2 - 3 times higher in seas than in still water. This, together with experiences from full scale trials, shows that so - called "service increase" of 25 - 30 % that is usual for larger cargo vessels does not have any meaning for fishing vessels of this size.

The high increase in resistance for this vessel size is connected with vessel length and wave height and also hull shape, especially bow shape.

This is therefore an area that we have tried to pay more attention to in the further work under this project. FTFI has received funds for systematic testing of fishing vessel hulls from 20 m length and up in still water and in waves (Project 672.210, New hull forms for fishing vessels of 20 m. length and above"). The project was financed from Efficiency Improvement Funds.

With respect to hull resistance, reference can also be made to Ref. B.62 and B.64, Project 672.178, " Testing of resistance reducing measures on fishing vessels". This project was financed through Efficiency Improvement funds for the ship model tank trials, and were completed in 1984 - 85.

In this project, the hull shape of a purse seiner was developed and a vessel of this shape built in the fall of 1985.

Compared with fishing vessels that were tested in the model tank in the 1970's, this hull exhibited a 10 - 30 % improvement in resistance. This was achieved by putting emphasis on shaping the bow and stern.

In addition the shape of the stern was designed for a large, effective propeller with a low noise level.

In this project, experiments were also performed with a bow tank open to the sea with the purpose of reducing movements and resistance. The results were positive enough to encourage us to apply for funds for further testing of the principle.

With respect to utilization of the model test data, references B.31 and B.32 can be mentioned. These reports give

regression analyses of still water data from trials with fishing vessel hulls performed at Marinetek and the Ships Technological Laboratory et.al.

Limitations of these trials and the completed analyses are that the material only includes still water trials and applies to the higher speed ranges for the individual vessels.

The ideal goal with respect to resistance data would be to perform a systematic series with trials in still water and in waves. The results from a series like that together with earlier trials would then form the basis for an analysis of movements and resistance increases in waves. Such analytical results would be a desirable addition for use in projections and designs of fishing vessels.

The project has in this period followed some conversion projects which include replacement of propulsion systems. These include the motor vessels Harjan, Dagny Kristin, Sjøvik and Persfjord where we have assisted through measurements taken before and after the conversion.

The first projects were of considerable importance as demonstration objects to illustrate fuel savings in the fishing fleet, both on prospective conversions and for new constructions. The results from this project have been developed further as themes in the literature and other information material used in our information campaign on fuel savings in the fishing fleet.

A number of talks have been held based on results from the project. These include Re. (B.22), (B.23), (B.45), (B.48) and (B.55).

On the subject of alternative propulsion methods , the following work was done :

- A 70 - ft fishing vessel (M/V Kvaløyvaer) was rigged with sail in 1983. We intended to perform simple measurements (roll damping and propulsion), but did not get funding for this. Information received from the owner indicates that the vessel, with the relatively small sail area, reduces the engine effect with 10 -15 % in relatively light wind at the same speed.
- With extra allocated funds, full scale measurements with passive foil operation was carried out on M/V Kystfangst (Ref. B.57 and B.58). Additional propulsion corresponding to 15-20 % of the vessel resistance was registered in special situations. When this report is being written , Veritas in Oslo is working on an analysis of foil propulsion in fishing vessels. A study by stud. tech. Arild Jaeger also included the cost of foil operation.

The project " Full scale measurements of speed loss in rough seas" (672.141), should according to the plan include development of instrumentation for the best possible measurements of resistance and movements on a full scale for a fishing (p.20) vessel. The project is externally financed with respect to instrumentation, programming etc. The work with development of the equipment has become so extensive that there has been no room for the full scale measurements as planned.

The instrumentation has now been produced and was tested onboard in the fall of 1986. Funds have been applied for to

perform extensive full scale measurements with the new equipment, but have not yet been approved.

These measurements will give us base data to better evaluate resistance and movements in waves on the project level.

Under this project a comparison between theoretical calculations and measured additional resistance in waves (model scale) was performed. Ref. (B.44).

Other model tests and full scale measurements will give a better basis for improving the theoretical methods so that they can be used in projection work also for smaller vessels.

Full scale measurements with M/V "Kystfangst" after conversion to install a new bow has been performed. The reduction in resistance is 20 - 30 % in the speed range of 7 - 10 knots in still water (model and full scale). Model tests had earlier shown that the reduction in resistance in waves is ca. 15% if the model results can be applied to full scale for wave heights 2 - 4 m.

A propulsion system with hydraulic transmission to the propeller axle on a 41 ft research vessel was also installed in the project period. The transmission system have several advantages with respect to locating the engine. Measurements showed that a large propeller with slow rotation can be justified also on vessels in the sjark size. (Ref. (B.41).

The M/V "Sjøvik" was the first Norwegian fishing (p.21) vessel that had a main engine installed with the capability of using heavy oil.Experiences from installation and operation of this unit are given in references (B.56), (B.63), (B.65), (B.66) and (B.69).

Data have been collected for motors, reduction gear and propeller systems suitable for fishing vessels. The data are presented in a report, ref. (B.59). A report covering engines has been issued earlier.

The project "New hull shapes for fishing vessels in sizes 20 m and up" started in the fall of 1986, and will be completed in the first half of 1987. The basis was a lack of trials in still water and in waves for the smaller vessel sizes, and that

individual owners find it too expensive to perform model tank experiments. The basic model in the trial series is a 65 ft shrimp trawler (70 GRT) that was lengthened and had the bow changed. The trials were run in still water and in regular and irregular waves.

Additional resistance and movements in moderate or heavy seas are a problem for small vessels, ref. (B.67). In that connection there was work done to develop methods for using data from hull trial in waves. Analytical tools in the form of a computer program that will simplify the work of processing model tank data from wave trials was developed, ref. (B.68).

4.1. DOCUMENTATION 662.5-2 (B).

(B.1) J. Husvik: User description for computer program for HP 67/97 for resistance calculations. Working paper 16/1 -1980.

(B.2) J. Husvik: M/V Kystfangst. Resistance and propulsion properties. FTFI Report ISBN 82-7251-065-9

(B.3) J. Husvik: Possibility for large payoffs with correct construction and use of the controllable pitch propeller. Working paper 30/5-1980.

(B.4) J. Husvik: Model trials with bulb on M-1398. Note 6/6-1980.

(B.5) J. Husvik: Evaluation of model experiments on the Trondheim Fjord and in SMT. Working paper 18/6-1980

(B.6) A. Markussen: Losses in controllable pitch propellers at zero propulsion. Working paper 1/7-1980

(B.7) A. Aakre: Bow form variations for combination vessels in the 110 ft. class. NHL Report No. 180058, 12/12-1980.

(B.8) Aa. Berg: Full scale measurements on M/V "Harjan" before conversion. Working paper 13/7 - 1981.

(B.9) A. Aakre: Stern and bow variations for 110 ft. fishing vessel. NHL Report No. 181084.

(B.10) Aa. Berg: Program for simple propeller calculation. Working paper 11/8 - 1981.

(B.11) Aa. Berg: Full scale measurements on M/V "Harjan" before conversion. Working paper 13/7- 1988.

(B.12) Aa. Berg: M/V "Kato" Working paper 18/8 - 1981.

(B.14) A. Aakre: 110-ft combination vessel with two types of bow form in waves.
NHL Report No. 181211 dated 31/3 - 1982.

(B.15) B.S.Gulbrandsen: Seakeeping test M-1522 B M/V "Harjan".
NHL Report No. 182037. Feb. 1982.

(B.16) B.S.Gulbrandsen: Still water trials, purse seiner M/V/ "Harjan" before and after conversion.
NHL Report 182039. March 1982.

(B.17) Aa. Berg: Full scale measurements M/V Harjan. After conversion.
Working paper 15/1 - 1982.

(B.18) A. Løvik, J. Syrstad: Measurements on M/V "Harjan".
ELAB Working paper (noise measurements), 441386.03, No. 52, 8/2-1982

(B.19) A. Løvik: Measurements of M/V "Harjan".
SINTEF Report STF 44 A82 161
ISBN No. 82-595-2795-2.

(B.20) Aa. Berg: FTFI News: Save fuel with large propeller (Dedicated to the "Harjan" project.)

(B.21) Aa. Berg: News on fishing. Talk on fuel savings.

(B.22) Aa. Berg: Use of engine and propeller. Improvements through conversion of the propeller system.
Seminar on fuel savings on trawlers.
Dated 9/12 - 1982.

(B.23) Aa. Berg: Full scale experiences with propeller re-installation on a purse seiner.
Presented on RINA Conference on Small Craft Propulsion in London, Nov. 1982.

(B.24) Aa. Berg: Noise reduction/Air inlet, M/V "Kystfangst"
FTFI working paper, Dec. 1982.

(B.25) Aa. Berg: Save fuel with large propeller.
News on the OILFISH Project. (A reprint of FTFI News dedicated to the Harjan project. Published by Nordforsk, Copenhagen.

(B.26) K. Holden: Model trial , noise , and pressure impulse measurements. Old / new propeller. M/V "Harjan". NHL Report No. 183236, June 1983.

(B.27) A. Aakre: The influence of length - width relationship on the energy consumption of fishing vessels in still water. NHL report No. 182093 dated 23/12 -1982.

(B.28) Aa. Berg: "Dagny Kristin - Full scale measurements" Two page note dated 24/3 - 1983. FTFI.

(B.29) K.Henriksen and C.J.Bang: Resistance trials with M/V "Kystfangst". SL - Report No. 83020, 30/5 - 1983.

(B.30) Aa. Berg: "Lofottrål I". Registrations on a full scale in still water and waves. FTFI Working paper dated 20/6-1983.

(B.31) T.Digernes and Chen Ming Yi: Regression analysis of model resistance, Norwegian and Danish vessels. Working paper 5/7-1983.

(B.32) T.Digernes and Chen Ming Yi: Resistance regression - deviation tables for individual vessels. Working paper 7/7 - 1983.

(B.33) I.Carlsen: Noise measurements of M/V "Dagny Kristin". ELAB Report STF 44 483191.

(B.34) A. Aakre: Influence of the length - width relationship and magnitude of longitudinal radius of inertia on seagoing properties. NHL Report No. 183191.

(B.35) I. Bjørkum: Hydrostatic operation of propeller on 41 foot shark. Working paper.

(B.36) J.U.Rømeling, C.J. Bang: Resistance test in waves with fishing vessel M/V "Kystfangst". SL 83114 and film.

(B.37) N.H.Bjørshol: Full scale measurements. M/V "Eidefisk". Working paper.

(B.38) Aa. Berg: Full scale measurements, M/V "Dagny Kristin". Working paper.

(B.39) A. Aakre: Influence of propeller nozzle and hull fullness on propulsion properties and seagoing movements.
NHL Report 183339, 1984.03.30.
(NFFR project).

(B.40) A. Aakre: Results from model tests in still water and waves with longline vessel M-1597.
NHL Report 183338, January 1984.

(B.41) I. Bjørkum: Results of measurements on the hydraulic propulsion system on M/V "Fjordfangst".
Working paper 25/6 - 1984.

(B.42) N.H. Bjørshol: Full scale measurements onboard M/V "Eidefisk".
Working paper 21/5 - 1984.

(B.43) N.H. Bjørshol and Aa. Berg: Testing of passive foil propulsion on M/V "Kystfangst".
Working paper, 21/3 - 1984 (672.138).

(B.44) G. Olsen: Comparison of measured and calculated additional resistance for fishing vessels in model scale.
Work under special grant,February 1984.
NHL report UR-85-43.

(B.45) I. Bjørkum: Energy efficient propulsion systems; choice of propeller diameter and matching of engine and propeller.
Talk presented at "Oil-fish" seminar, 10/8 - 1984.

(B.46) N.H.Bjørshol and Aa. Berg: Testing of passive foil propulsion on M/V "Kystfangst".
Working paper 12/6 - 1984 (672.138-2).

(B.47) S.Brinch-Nilsen: Preliminary study for analysis of foil propeller.
Veritech Report No. 84-3371, 10/7 - 1984.

(B.48) Aa. Berg: Construction of energy efficient fishing vessels. Hull shapes and propulsion systems.
NOR - FISHING 9/8 - 1984.

(B.49) R. Riksheim, A. Øydvin: Propulsion trials. Project purse seiner and trawler. (672.178).
NHL Report 184479, Nov. 1984.

(B.50) Aa. Berg: M/V "Persfjord" ; full scale measurements.
FTFI Project 672.176, dated 3/1 - 1985.

(B.51) Aa. Berg: Practical testing of bulbous bow types for fishing vessels.
FTFI project 672.139, dated 4/2 - 1985.

(B.52) A.Øydvin: Propulsion and towing trials with a 160 ft purse seiner/ trawler.
NHL Report 185026, dated 26/2 - 1985.
(FTFI project 672.178).

(B.53) K.E.Kristensen and I. Carlsen. Noise measurements on M/V "Persfjord".
ELAB Report STF 44 A 85088, dated 10/4-85.
(FTFI project 672.176).

(B.54) R. Riksheim: M/S "Persfjord". Model tests with altered stern.
Marintek Report 510070-85,dated June 1985.
(FTFI Project 672.176).

(B.55) Aa. Berg, I. Bjørkum, T.Digernes: Fuel savings in the operation and construction of fishing vessels.
FTFI Report 662.5-3, dated 26/6 - 1985.

(B.56) I. Bjørkum: Heavy oil operation, M/V "Sjøvik".
Introduction to report.
FTFI Working paper 672.174 of 2/7 1985.

(B.57) Aa. Berg: Testing of passive foil operation on M/V "Kystfangst".
FTFI Working paper 672.138 of 4/7 1985.

(B.58). Aa. Berg: Trials with passive foil propulsion.
FTFI Report on project 672.138, dated 17/7 1985.

(B.59) L. Waerdahl: Gear and propeller systems for fishing vessels.
FTFI Report 3/9 1985.

(B.60) A. Øydvin, Propulsion trials with a 160 ft purse seiner/ trawler with bulbous bow installed
Marintek Report 510101-2, dated 23/10 85
(FTFI project 672.178).

(B.61) A. Øydvin: R. Riksheim: Trials in seas with irregular waves, 160 ft purse seiner/trawler.
Trials with intact ship and with anti-pitch tank open to the sea.
Marintek Report 510101-3, dated 20/11 85.
(FTFI project 672.178).

(B.62) Aa. Berg: Testing of resistance reducing measures on fishing vessels.
FTFI Report summary, note 672.178 of 12/12 1985

(A.63) I. Bjørkum: Description of the engine system on M/V "Sjøvik.
FTFI Working paper, 18/12 1985.

(B.64) Aa. Berg: Guidelines for shaping hulls.
FTFI Report 672.178, January 1986.

(B.65) I. Bjørkum: Heavy oil operation on M/V "Sjøvik".
FTFI Working paper dated 14/1 1986.

(B.66) I. Bjørkum: Experiences with heavy oil operation on M/V "Sjøvik".
FTFI Working paper dated 1/7 1986.

(B.67) R. Pedersen: Additional resistance and movements in seas.
FTFI note dated 30/12 1986.

(B.68) B. Enerhaug: Computer program for working up model trial results.
FTFI Note dated 22/12 1986.

(B.69) I. Bjørkum, J. Storøy: Heavy oil operation on fishing vessels.
FTFI Report 672.174.

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5.0 MACHINERY AND SYSTEM DEVELOPMENT

Sub-Project C (662.5-3).

This project started in 1974, but was included in the energy efficiency program from 1980 and was concluded at the end of the same year.

The objectives for 1980 were as follows:

- Develop a basis for dimensions and procedures for use in the projection of machinery for fishing vessels.
- Develop new solutions for machines and equipment for fishing vessels that will result in safety, environmental or economic advantages.
- Project engine systems and perform technical and economic analyses of alternative engine systems for actual vessel projects.

Results.

The work by staff in the vessel section on the gear problems on M/V/"Kystfangst" was financed through this project and the work consumed a substantial part of the section capacity in this period.

Much of the activity was otherwise concentrated on energy saving projects. Instrumentation was installed onboard M/V "Kystfangst" to obtain better data on the effect and how the effect was utilized. This instrumentation has given us better knowledge in the work on energy efficiency. The equipment also functioned well in later demonstrations during the fuel saving campaign.

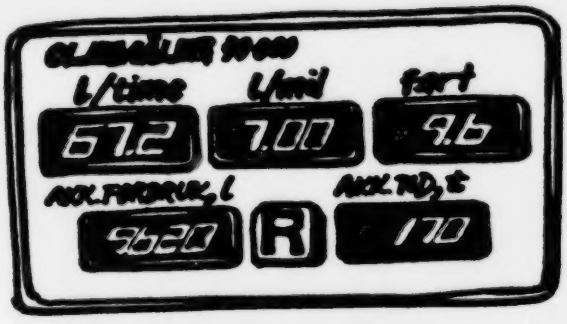
A number of talks on energy efficiency in the fishing fleet were held based on the results of the project (also before 1980).

Some introductory experiments with ecopilot were performed onboard M/V/"Kystfangst". The computer and program functioned relatively well, but with some problems with the sensors.

(p.30)

(p.29)

Spar drivstoff



OLJEMÅLER GIR OGSÅ INFORMASJON OM:

- Hvordan forbruket påvirkes av båtens trim
- Motstandsegenskaper i sjø og vind
- Tilstand i motor, propell og skrog
- Varsler om motorens belastning

An oil meter also gives information on:

-How consumption is affected by the trim of the vessel.

-Resistance properties in waves and wind.

-Conditions of engine, propeller and hull.

-Gives warning of the load on the engine.

In connection with purse seine trials onboard M/V "Kystfangst", practical trials with an unmanned and radio guided towing skiff were performed (ref. C.15).

The project was divided on January 1, 1981. Typical engine activities were transferred to the project "Development of new vessel types" (662.3). Activities regarding economics were continued under "Energy efficiency in the fishing fleet" (662.5-1).

5.1. DOCUMENTATION 662.5-3 (C). (p.31)

(C.1) I. Bjørkum: Delivery of new gears for M/V"Kystfangst". FTFI Note 15/2 1980.

(C.2) A.Farstad: Operational problems with gear - and propeller system onboard M/V "Kystfangst". FTFI Note 3/3 1980.

(C.3) I. Bjørkum: The gear break down on M/V "Kystfangst". FTFI Working paper 11/6 1980.

(C.5) T. Digernes: The ecopilot system on M/V "Kystfangst". FTFI Working note 10/3 1980.

(C.6) A.Endal and A. Markussen: Fuel saving on fishing vessels, engines, propellers and auxiliary systems. Talk given at a meeting in Aalesund Vessel Owners Association, 26/6 1980.

(C.7) A. Endal: Fuel saving potential in Norwegian Fisheries. Talk given at ICES meeting in Reykjavik.

(C.8) L. Waerdahl: Variomatic operation of alternate current generator. FTFI Working paper 10/4 1980.

(C.9) I. Bjørkum: Remote steering and regulation of the engine system on M/V "Kystfangst". FTFI Note 14/3 1980.

(C.10) N.H.Bjørshol: Energy efficiency on trawlers. FTFI Note 24/10 1980.

(C.11) I.Bjørkum: Logging of fuel oil consumption and operational profiles on fishing vessels. FTFI Note 14/10 1980.

(C.12) I. Bjørkum: The propulsion system - gear break down on M/V "Kystfangst". FTFI Note 6/11 1980.

(C.13) I. Bjørkum: Economical use of machinery: Talk at NIF course in Aalesund, 2/12 1980.

(C.14) A. Endal: Alternative propulsion systems. Future developments. Talk at NIF course in Aalesund 2/12 1980.

(C.15) A. Beltestad, I . Bjørkum, O.Chruickshank and K. L. Olsen: Preliminary report on purse seining trials with new ring threading system and radio controlled towing skiff on M/V "Kystfangst". FTFI Working note 1/11 1980. (P.32)

(C.16) N.H. Bjørshol: Description of ecopilot instruments on M/V "Kystfangst".

6.0. TACTICAL RESOURCE PROJECTIONS.
Sub-project D (662.5 - 3).

The project was initiated in the second half of 1982 with the following objective:

Development of information systems for fishing conditions and decision models that will improve the basis for decisions by the skipper regarding the operation of the vessel.

The work of the project was divided into two areas:

a) Evaluation of information requirements and systems for collection and dissemination such information to the fleet.

b) Development of a system for use onboard by the skipper to assist in his decisions.

Results.

The first version of a decision model for calculating expected economic results of alternative decisions was oriented towards trawlers.

An information system that at the same time was under development at the University of Iceland, should according to the plan be integrated with the decision model being designed under the project.

The finished system should according to the plan be tested by skippers invited to FTFI to evaluate the system.

The value of the project should be in improved flow of information that should again lead to :

- reduction of lost time and fuel for searching for fish and moving between fishing grounds (and landing port).
- improvement of fleet utilization and vessel profitability

This sub-project was terminated as of December 31, 1984 with the following status:

- A prototype information system for catch data is available (developed at the University of Iceland as a cooperative effort). The system has been further developed and

improved somewhat at FTFI.

- A prototype decision model developed at FTFI is available. The model demonstrates decision requirements, calculations and presentation of results in a model that can be used in connection with decision and choice of fishing grounds.

- The plan to combine the two models has been scrapped. The reason is that the labour input to modify and match the two systems was judged to be too great to be justified. The result of the combination would still only be a demonstration model with little more to show than what could be achieved separately by the two part systems.

- A system for practical use onboard would require a considerable effort above what has been expended on the project to the end of 1984.

Later projects.

The work that has been started on the project "Tactical resource projections" has later been completed under other projects.

Reference (D.3) refers to a note prepared on the project "Decision model onboard" (672.189). A model is here sketched out that could be used on most of the deep-sea trawler fleet fishing with bottom trawl, and also for offshore longline , gillnet and Scottish seine vessels.

It remains to test the model in practice on a selected vessel.

Reference (D.4) " Information technology in the Fisheries" discusses how we can utilize the technological opportunities in situations that are economically profitable for the fisheries. It is pointed out that need for information technology is present in all stages of the industry, from the resource side to the marketing side.

Reference (D.5) refers to a report from the working seminar "Information Technology in the Fishing fleet" held in Stjørdal on January 23-24, 1986. An attempt was here made to draw up the

principal lines of development in future work in this field and current research and development areas were identified.

The hope is to get "Information Technology in the Fishing Fleet" included as a regular part of the Government priority area of "Information Technology".

6.1. DOCUMENTATION 662.5-3 (D). (p.36)

(D.1) T.Digernes: Tactical resource information; opportunities and perspectives. Note 28/10 1983.

(D.2) I.Arnarsson: Proposal for a decision model for use by Icelandic fresh fish trawlers. Note/student project, fall 1982.

(D.3) T. Digernes: Decision model onboard. FTFI Note 28/8 1982.

(D.4) T. Digernes: Information technology in the fisheries. FTFI Note 19/9 1985 (666.3-1).

(D.5) NFFR: Information technology in the fishing fleet. Report from working seminar 23 - 24 January 1986.

7.0. RECOVERY OF WASTE HEAT. Sub-project E 662.5-4).

This project was started in 1979 and included in the energy project for continuation in 1980.

The objective for the project was as follows:

- Develop systems for recovery and utilization of waste heat from the main engines of fishing vessels.

Results.

After theoretical studies were performed in 1979, the plan was to continue with practical experiments onboard M/V "Kystfangst" in 1980.

An arrangement for de-icing the railing with the help of cooling water from the main engine was installed onboard. Since the vessel did not operate during the coldest part of the winter, it was not possible to test the system.

The project was terminated in 1980 without practical tests having been performed.

It should also be mentioned that under the Nordforsk research project "Oil/Fish", work was done on Danish and Icelandic projects regarding utilization of waste heat.

7.1. DOCUMENTATION 662.5-4 (E). (p.38)

(E.1) N.H. Bjørshol: Note dated 28/11 - 1979.

8.0. OPERATIONAL INSTRUMENTATION AND MEASUREMENTS FOR FUEL EFFICIENCY.

Sub-project F (662.5-4).

This sub-project was segregated from 662.5-1 "Energy efficiency in the fishing fleet" from 1/1 1983, and did not represent new directions within the energy efficiency program.

The program was underway in the 1983-86 period with the following objectives:

a) To complete the program of measurements to obtain data on energy consumption and operational profiles for fishing vessels. This will form the basis for analyses of the energy efficiency during operations of the vessel.

b) To test and develop instrumentation that can be used onboard to improve the fuel efficiency of the vessel under operational conditions.

Results.

The progr arted under sub-
project A to ob ing vessels was
continued. Dat vessels equipped
with data loggi

There were the measurements
ue to failure siderable amount
of data has, h s.

The fuel meter. The key to oil savings. Econometer.

According to the plan a fifth vessel, a longliner, should also have data logging equipment onboard for a period after we had finished the measurements on the first four. This has not happened. The data we now have are obtained from the fresh fish trawler "Lofottrål I", the purse seiner "Harjan" (shipwrecked 1984), the industrial trawler "Eidefisk" and the research vessel "Kystfangst".

Under the project, work has also been performed on a sensor for fuel consumption based on the use of ultrasound, ref. (F.5). This meter has no movable parts that can lead to blockages due to impurities in the oil. A prototype of the meter has been tested under laboratory conditions. The results have so far been promising enough for us to decide to develop it further. We have received efficiency improvement funds for this work.

Some full scale measurements were also done under the project in connection with conversions of fishing vessels. Reference is made to the literature list for this project and for sub-project B. The results from such measurements have been very important for use in information programs on fuel saving measures.

Instrumentation for measuring speed losses and vessel movements in seas was developed under the project "Full scale measurements of speed loss in seas" (672.141). Equipment for registering up to 16 channels is built into a suitcase that can be carried around.

The new equipment will mean a great improvement with respect to both the taking of the measurements themselves and the work to analyze the data. A series of measurements will probably be done in 1987 onboard a vessel with suitable instrumentation.

The analytical program ENDAFI for working up the data for energy consumption is now operational on VAX 11.785. The work with this program was stopped in 1984 because the program became too big for the HP 1000 computer that the program was developed on.

The part of the program that works up the raw data and

produces the distribution of running conditions has been tested and found to be in order so far. The raw data available, ca. 4.5 Mb, have been transferred to the computer or are ready to be transferred for calculation. The data will be available for further treatment, for example with the use of the time series analytical program CYPROS. Further analytical work will be very suitable as a student project.

"The fuel consumption simulator" is a computer program that was developed on VAX in 1983-84. The simulator is a training aid for teaching fuel economy in fishing vessels. The work to transfer the program to an IBM-AT compatible PC was done in 1986. The program is written in Pascal and require computers in the price class 40 to 50 thousand kroner. Documentation is built into the program and is also available in a written form.

8.1. DOCUMENTATION 662.5-4. (F). (p.42)

(F.1) Aage Berg: Full scale measurements M/V "Sjøvik" Working paper FTFI 15/9 1983.

(F.2) Aage Berg: Full scale measurements M/V "Sjøvik" after conversion. FTFI Working paper, 21/3 1984.

(F.3) Alain Ferber: Full scale measurements of speed losses in seas. Development of instrumentation suitcase. FTFI Note 18/10 1985.

(F.4) Aage Berg: Test trip measurements M/V "Harjan", 16/10 1985. Working paper 13/12 1985.

(F.5) N.H.Bjørshol: Testing of prototype of acoustic oil meter. Working paper dated 13/12 1985.

(F.6) A. Ferber: "Gyro box". FTFI Report dated 21/7 1986.

(F.7) N.H.Bjøpshol: Ecopilot onboard the fishing vessel M/V "Eros". FTFI Report 1986.

9.0 ACCOUNTS.

Year	Total budget	Total costs
År	**Total-budsjett**	**Total-kostnader**
1980	1.129.000,00	992.159,04
1981	1.635.000,00	1.735.364,86
1982	2.015.000,00	2.053.295,00
1983	2.789.000,00	3.047.549,00
1983	2.350.000,00	2.358.165,00
1985	1.450.000,00	1.501.436,88
1986	800.000,00	800.000,00
Totalt	12.168.000,00	12.487.969,78

10.0. CONTINUATION.

At the time this report was written, it was desirable to continue some of these activities.

This applies to the following:

a) The operational profile data that were obtained through project 662.5-4 (F) should be further analyzed. This work could be performed, for example, with the help of the time series analytical program CYPROS which is now available at FTFI. The analytical work would be suitable as a student program.

b) Computer program for diagnosis calculations. The program has been started and almost completed within the budget of the information campaign. Some programming work remains at year end 1986/87.

The program was intended to be used in the planned diagnosis program which was to be offered in the extension of the information program.

The program would also be very suitable as a projection tool in connection with technical and economic evaluations.

C) Prediction of resistance and movements for fishing vessels on the projection level is an area where further work should be done.

We have through the energy program and other projects attempted to complete the measurements available for fishing vessels (model and full scale trials).

To be able to perform good analyses of such measurements it is necessary to have a larger database than that we have available today.

We must therefore attempt to perform model tests (p.45) with systematic variation of hull parameters to get information on resistance in still water and incremental resistance and movements in waves. This will give us a better basis for projection and for carrying out analyses of the total economy for

fishing vessels of a given width and with variable lengths.

Regression analyses of resistance increases and movements in waves should also be done based on the few experimental data we have available for fishing vessels. Incremental resistance and movements are analyzed from wave (seas) parameters and different combinations of hull parameters.

d) Work on further development of the fuel meter based on the transmission time principle should be continued. Part financing of the project has been approved through the Efficiency Improvement Fund and the rest must be found through an industry partner.

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